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FUEL INJECTION CONTROL DEVICE FOR REFORMED-GAS ENGINE
[Kaishitsugasu enjin no nenryoufunsha seigyosouchi]

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SPECIFICATION /243*

1. Title of the Invention

FUEL INJECTION CONTROL DEVICE FOR REFORMED-GAS ENGINE

2. Claim

(1) A fuel injection control device for a reformed gas engine comprised of: a reforming apparatus that reforms a liquid fuel into a hydrogen-rich gas; a gas injection valve that is provided next to the induction system of the engine and that becomes intermittently opened and closed by means of driving pulse signals that are synchronized to engine revolutions; a gas shutoff valve disposed between the above-mentioned reforming apparatus and the above-mentioned gas injection valve; a gas pressure sensor provided to the upstream side of the above-mentioned gas shutoff valve; a basic injection amount calculating means that calculates the basic amount of injected gas per single engine revolution or single injection in accordance with the engine's operation conditions; a gas flow calculating means that calculates the gas flow per unit time based on the above-mentioned basic gas injection amount and the engine revolutions; an injection-valve-part pressure calculating means that calculates the pressure loss based on the above-mentioned gas flow, that corrects the gas pressure detected by the above-mentioned gas pressure sensor, and that thus obtains the true gas pressure in the gas injection valve; a pressure correction coefficient calculating means that calculates a pressure correction coefficient based on the true gas pressure; a gas injection amount correcting means that corrects the above-mentioned basic gas injection amount based on the above-mentioned

* Numbers in the margin indicate pagination in the foreign text.

pressure correction coefficient; and a drive-signal output means that outputs a drive pulse signal to the above-mentioned gas injection valve in accordance with the corrected gas injection amount.

3. Detailed Explanation of the Invention

Field of Industrial Application

This invention pertains to fuel injection control devices for improved-gas engines in which a reformed gas, which is obtained by modifying a liquid fuel, is supplied to the engines.

Related Art /244

Liquid fuels, such as alcohol, can be modified into inflammable gases containing hydrogen and carbon monoxide as main components by being heated in the presence of a catalyst, and since the heat efficiency and emission properties can be improved in comparison to a case in which alcohol, etc. is combusted without alteration, reformed-gas engines in which such reformed gas is utilized alone or in combination with an unmodified liquid fuel are being highlighted.

In such a reformed-gas engine, a reforming apparatus that utilizes exhaust gas as a heat source is generally utilized in order to recover the heat of the engine exhaust. By controlling the supplied amount of a liquid fuel or by controlling the temperature of the reforming apparatus by adjusting the amount of an exhaust bypass gas, the reforming reactions are regulated in accordance with the operation condition. However, due to the responsiveness, etc., it is naturally impossible to stably supply a reformed gas at a constant pressure to the gas injection valve. In light of this, according to a conventional method indicated in Kokai No.52-113426, such pressure fluctuations are dealt with by pre-adjusting a reformed

gas generated by a pressure regulator to a constant pressure in order to secure a desired amount of fuel injection. However, this has problems in that, for example, the reformed gas cannot be efficiently utilized in an operation range (e.g., during a warm-up operation) in which the reforming performance is low. Therefore, a method in which a pressure sensor is provided to the reformed gas path and in which the gas injection amount of the gas injection valve is corrected in accordance with the detected pressure is being considered in recent years (e.g., Tokugan No.58-70309). However, even in such method in which the gas injection amount is corrected based on the detected pressure, a pressure loss occurs in the pipe, etc. on the downstream-side of the gas pressure sensor, and it cannot be said that the true pressure of the reformed gas is measured at the gas injection valve, unless the above-mentioned gas pressure sensor is provided immediately before the gas injection valve. This becomes a relatively major error factor when trying to control the excess air ratio at a high accuracy. In particular, a gas shutoff valve, which is for preventing the gas from leaking usually while the engine is stopped, is provided between the above gas injection valve and the reforming apparatus. In order to monitor a change in the gas pressure by utilizing the above gas pressure sensor during a warm-up operation in which said gas shutoff valve is closed, the gas pressure sensor must be provided on the upstream side of the gas shutoff valve. For this reason, the location provided with the gas pressure sensor inevitably becomes separated from the gas injection valve, and this, together with the above-mentioned pressure loss caused by the gas shutoff valve, causes a major error.

Purpose of the Invention

This invention was completed in light of the above conventional problem, and its purpose is to more accurately correct the injection amount of a reformed gas in accordance with its pressure fluctuation by eliminating the influence of a pressure loss that occurs in the gas shutoff valve or in the pipe on the downstream side of the pressure sensor.

Structure of the Invention

A fuel injection control device for a reformed gas engine of the invention is, as indicated in Figure 1, comprised of: a reforming apparatus [A] that reforms a liquid fuel into a hydrogen-rich gas; a gas injection valve [C] that is provided next to the induction system of the engine [B] and that becomes intermittently opened and closed by means of driving pulse signals that are synchronized to the engine revolutions; a gas shutoff valve [D] disposed between the above-mentioned reforming apparatus [A] and the above-mentioned gas injection valve [C]; a gas pressure /245
sensor [E] provided to the upstream side of the above-mentioned gas shutoff valve [D]; a basic injection amount calculating means [F] that calculates the basic amount of injected gas per single engine revolution or single injection in accordance with the engine's operation conditions, such as the acceleration control amount [a], intake air flow [b], engine revolutions [c], etc.; a gas flow calculating means [G] that calculates the gas flow per unit time based on the above-mentioned basic gas injection amount and the engine revolutions; a injection-valve-part pressure calculating means [H] that calculates the pressure loss that occurs in the gas shutoff valve [D] or in the pipe on the downstream side of the gas pressure sensor [E] based on the above-mentioned gas flow and that corrects the gas pressure detected by the above-mentioned gas pressure

sensor [E] as much as the pressure loss to obtain the true gas pressure in the gas injection valve [C]; a pressure correction coefficient calculating means [I] that calculates a pressure correction coefficient based on the true gas pressure; a gas injection amount correcting means [J] that corrects the above-mentioned basic gas injection amount based on the above-mentioned pressure correction coefficient; and a drive-signal output means [K] that outputs a drive pulse signal to the above-mentioned gas injection valve [C] in accordance with the corrected gas injection amount. The difference between the gas pressure detected by means of the gas pressure sensor [E] and the true gas pressure in the gas injection valve [C] is estimated based on the gas flow in the above-described manner, and the detected gas pressure thus becomes corrected. As a result, the gas injection amount can be controlled even more accurately as a weight flow.

Embodiment of the Invention

Figures 2 ~ 4 indicate an embodiment in which the invention is applied to a reformed gas engine in which a reformed gas and an unmodified liquid fuel are used in combination in accordance with the operation condition.

In Fig. 2, [1] is an engine, [2] is its intake path, and [3] is its exhaust path. The above-mentioned intake path [2] is provided with an electromagnetic gas injection valve [5] on the downstream side of the throttle valve [4] and is also provided with an electromagnetic liquid-fuel injection valve [6] near an intake port. [7] is an air flow meter that is for detecting the intake air flow, [8] is an air cleaner, and [9] is a sensor for the amount of acceleration manipulation. The above exhaust path [3] is provided with a reforming apparatus [10], and the amount of

exhaust that flows through the reforming apparatus [10] is controlled by means of an exhaust bypass valve [12], the opening of which is controlled by a negative-pressure actuator [11]. In addition, [13] is an electromagnetic valve that controls the negative pressure supplied from a negative-pressure source to the above actuator [11].

[14] is a fuel tank that retains a liquid fuel, such as alcohol, and is connected to the fuel inlet [10a] of the above reforming apparatus [10] through a liquid fuel path [18], which is provided with a constant-pressure pump [15], flow-control electromagnetic valve [16], and a check valve [17], and is also connected to the above-mentioned liquid fuel injection valve [6] via an injection path [19], which branches off on the upstream side of the flow-control electromagnetic valve [16]. [20] is a return fuel path.

A gas outlet [10b], from which a gas that was reformed in the above-mentioned reforming apparatus [10] is extracted, is connected to the gas injection valve [5] via a gas path [22] provided with a gas cooling apparatus [21]. The gas path [22] is provided with a gas pressure sensor [23] on the downstream side of the gas cooling apparatus [21] and is also provided with a gas shutoff valve [24] on the even more downstream side. The gas cooling apparatus [21] exchanges heat between engine cooling water and reformed gas, and the temperature of the engine cooling water is detected by means of a cooling water temperature sensor [25].

[26] is a crank angle sensor provided to a distributor [27] in order to detect the revolutions of the engine [1]. [28] is a catalyst /246 temperature sensor that detects the temperature of the catalyst inside the reforming apparatus [10], and a control unit [29] controls the gas

injection valve [5], liquid fuel injection valve [6], flow-control electromagnetic valve [16], etc. based on signals from these sensors, [7], [9], [23], [24], [25], and [28]. As indicated in Fig. 3, the above-mentioned control unit [29] is comprised of an MPU (central processing unit) [31], a program for controlling the MPU [31], a ROM [32] in which prescribed data is written, a RAM that temporarily stores external data, and an I/O [34] that processes input signals and output signals. In addition, this control unit [29] also controls the ignition time, idle revolutions, etc. and is connected to each type of sensors and actuators used for the controls.

The control of the fuel supply amount executed by the control unit [29] will be explained briefly. Since a reformed gas has excellent fuel efficiency and exhaust characteristics and an unmodified liquid fuel has superb output characteristics, appropriate gas injection amount and liquid fuel injection amount are first calculated in accordance with the operation conditions of the engine, and opening times that correspond to them are set for the gas injection valve [5] and liquid fuel injection valve [6]. Drive pulse signals that correspond to the gas injection valve [5] and the liquid fuel injection valve [6] are output at the same timing or at continuous timings for every revolution of the engine [1], and their ON times correspond to the valve opening times, which are set in the above manner. In the liquid fuel injection valve [6], the fuel pressure is kept constant by means of a constant-pressure pump [15], and therefore, the weight flow of the fuel is in approximate proportion to the valve opening time. In the gas injection valve [5], however, the pressure and temperature of the injected reformed gas are unstable and therefore become corrected

as described later.

Incidentally, the amount of a reformed gas generated by the reforming apparatus [10] is controlled by adjusting the liquid fuel supply amount by means of the flow-control electromagnetic valve [16] in accordance with the injection amount of the gas injection valve [5]. At the same time, the opening of the exhaust bypass valve [12] is controlled by means of the electromagnetic valve [13] in order to keep the temperature of the catalyst of the reforming apparatus [10] within a temperature range that is optimum for reforming.

Figure 4 is a flow chart that indicates a control procedure in which the opening time of the gas injection valve [5] is set after the above-described corrections have been made in regard to the pressure and temperature. In the first ①, the acceleration manipulation, S, the engine revolutions, N, and the intake air flow, Qa, are read from the output signals of the acceleration manipulation sensor [9], crack angle sensor [26], and air flow meter [7], respectively, and the optimum gas basic injection amount, T_{PGO}, is calculated based on these conditions in ②. This gas basic injection amount, T_{PGO}, is the injection amount obtained in a single engine revolution (i.e. single injection) at the reference pressure and temperature (e.g. 4ata, 0°C). In the next ③, the gas flow, Gg, per unit time is obtained from the above gas basic injection amount, T_{PGO}, based on: $Gg = T_{PGO} \times N$. In ④, the gas pressure, Pgo, actually detected by means of the gas pressure sensor [23] and the cooling water temperature, Tw, detected by means of the cooling-water temperature sensor [25] are

input. In the next ⑤, the true gas pressure, Pg, in the gas injection valve [5] is calculated based on the equation: Pg = Pgo - KGg, wherein KGg indicates the pressure loss that occurs in the gas shutoff valve [24] or in the pipe on the downstream side of the gas pressure sensor [23] and wherein the coefficient K is provided in advance on a trial basis. In other words, by correcting the actually detected gas pressure, Pgo, in accordance with the gas flow, Gg, the error that occurs due to /247
the difference between the detecting locations is eliminated. Then, based on the true gas pressure, Pg, that was corrected in the above manner, the pressure correction coefficient, K_{PG}, is obtained in ⑥ from $K_{PG} = 4/Pg$.

Incidentally, in the present embodiment, the gas temperature, Tg, is obtained indirectly from the temperature, Tw, of the engine cooling water that flows through the gas cooling apparatus [21]. In other words, the gas cooling apparatus [21] cools down a reformed gas of about 300°C, which is sent from the reforming apparatus [10], to around 100°C by using the engine cooling water, and the gas temperature obtained after the cooling is correlated with the cooling water's temperature and the gas flow (One such example is indicated in Figure 5). In ⑦, the gas temperature, Tg, that corresponds to the gas flow, Gg, obtained in ③ and to the cooling water's temperature, Tw, input in ④ is looked up from a data table, which is provided in advance, and a temperature correction coefficient, K_{TG}, is obtained based on the gas temperature, Tg, from $K_{TG} = (273+Tg)/273$.

Then, based on the pressure correction coefficient, K_{PG}, and the temperature correction coefficient, K_{TG}, obtained in the above manner and

also based on other correction components, which are a gas injection valve flow correction coefficient, K_V, and a battery voltage correction, T_S, the opening time of the gas injection valve [5] is obtained from a relational expression, $T_{iG} = T_{PGO} \times K_V \times K_{PG} \times K_{TG} + T_S$, in ⑨.

Effects of the Invention

As is clear from the above explanation, a fuel injection control device of the invention for a reformed-gas engine is capable of eliminating an error that occurs due to a pressure loss caused by the piping, etc. without having a gas pressure sensor provided immediately before the gas injection valve and is therefore capable of controlling the excess air ratio even more accurately.

4. Brief Explanation of the Drawings

Figure 1 is a functional block diagram showing the structure of the invention. Figure 2 is a drawing for explaining the structure of one embodiment of the invention. Figure 3 is a drawing for explaining the structure of a control unit. Figure 4 is a flow chart for the control of the gas injection amount. Figure 5 is a drawing showing the correlations among the reformed gas' temperature, cooling water's temperature, and reformed-gas flow.

[1] = engine; [5] = gas injection valve;

[6] = liquid fuel injection valve; [7] = air flow meter;

[9] = acceleration manipulation sensor; [10] = reforming apparatus;

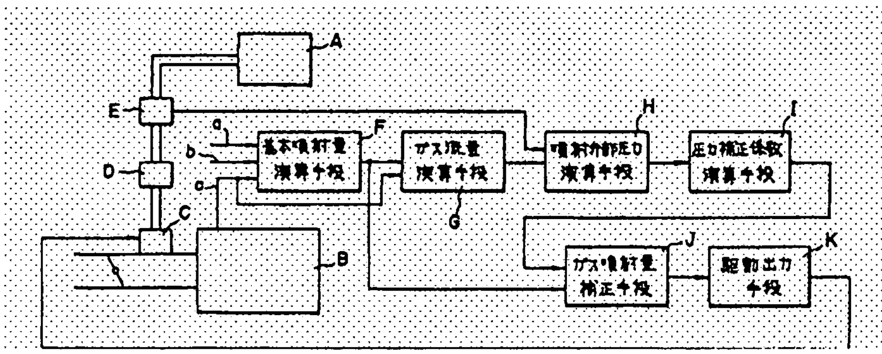
[12] = exhaust bypass valve; [14] = fuel tank;

[16] = flow-control electromagnetic valve; [21] = gas cooling apparatus;

[23] = gas pressure sensor; [24] = gas shutoff valve;

[25] = cooling water's temperature sensor; [26] = crank angle sensor; [28] = catalyst temperature sensor; [29] = control unit.

Figure 1



Key: F) basic injection amount calculating means; G) gas flow calculating means; H) injection valve pressure calculating means; I) pressure correction coefficient calculating means; J) gas injection amount correcting means; K) drive signal output means.

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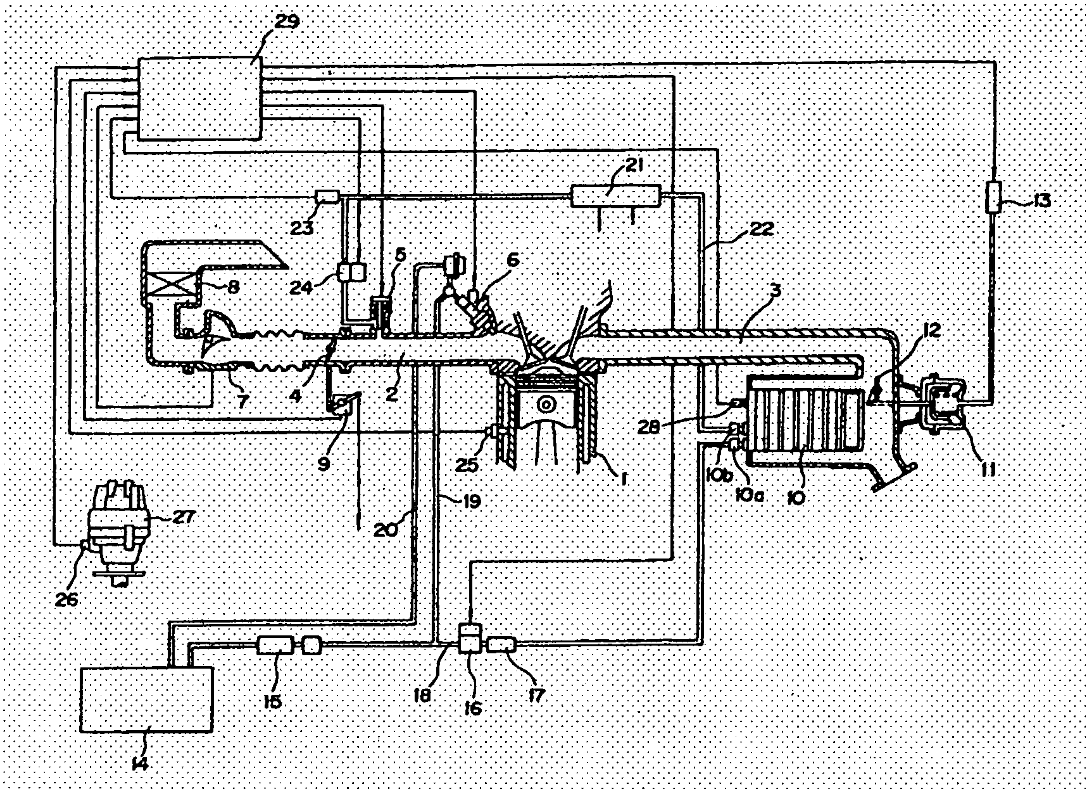
Figure 2


29
21
13
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7
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10a
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27
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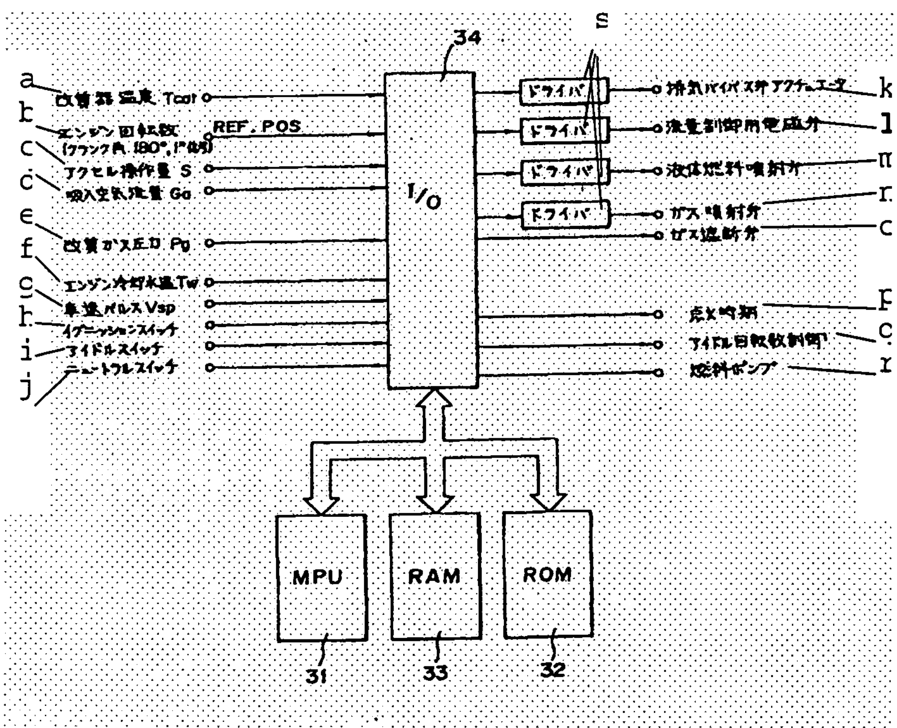
18
16
17
14

Figure 3


S
34
a
改質器温度 Tcat
b
エンジン回転数
(クランク角 180°, 1°信号)
REF. POS
c
アクセル操作量 S
d
吸入空気流量 Ga
e
改質ガス圧力 Pg
f
エンジン冷却水温 Tw
g
車速パルス Vsp
h
イグニッションスイッチ
i
アイドルスイッチ
j
ニュートラルスイッチ
I/O
ドライバ
ドライバ
ドライバ
ドライバ
排気バイパス弁アクチュエータ
k
流量制御用電磁弁
l
液体燃料噴射弁
m
ガス噴射弁
n
ガス遮断弁
o
点火時期
p
アイドル回転数制御
q
燃料ポンプ
r
MPU
RAM
ROM
31
33
32

Key for Fig. 3:
a) reforming apparatus temperature, Tcat; b) engine revolutions (crank angle 180°, 1° signal); c) acceleration manipulation amount, S; d) intake air flow, Ga; e) reformed-gas pressure, Pg; f) engine cooling water temperature, Tw; g) vehicle velocity pulse, Vsp; h) ignition switch; i) idle switch; j) neutral switch; k) exhaust bypass valve actuator; l) flow-control electromagnetic valve; m) liquid fuel injection valve; n) gas injection valve; o) gas shutoff valve; p) ignition time; q) idle revolutions control; r) fuel pump; s) driver.

Figure 4

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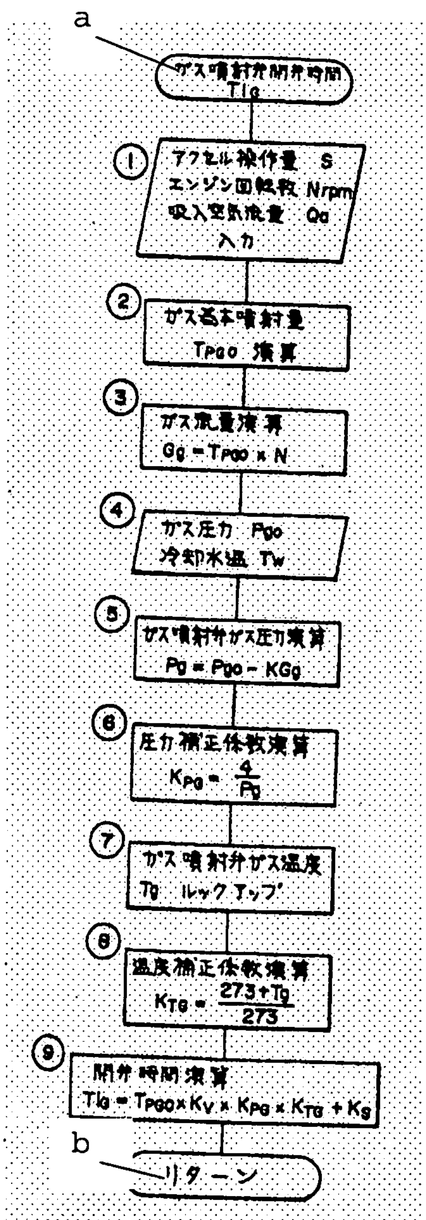
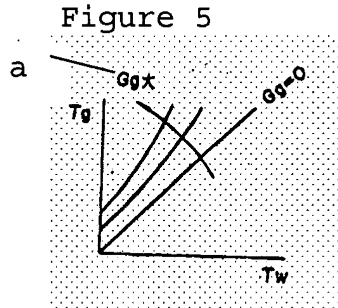


Key: a) Gas injection valve open time, Ti_G; 1) Acceleration manipulation amount, S, engine revolutions, Nrpm, and intake air flow, Qa, are input.; 2) Gas basic injection amount, T_{PGO}, is calculated.; 3) Gas flow is calculated, $Gg=T_{PGO}\times N$.; 4) Gas pressure, Pgo, and cooling water's temperature, Tw.; 5) Gas injection valve's gas pressure is calculated; $Pg = Pgo - KGg$.; 6) Pressure correction coefficient is calculated, $K_{PG} = 4/Pg$; 7) Gas injection valve's gas temperature, Tg, is looked up.; 8) Temperature correction coefficient is calculated, $K_{TG} = (273+Tg)/273$.; 9) Valve open time is calculated, $Ti_G=T_{PGO}\times K_V\times K_{PG}\times K_{TG}+K_S$.; b) Return.

Figure 5



Key: a) Gg increases.